Air Mass Characterisation During EOPACE: Aerosol Composition and Concentration

Michael H Smith
Centre for Marine and Atmospheric Sciences
School of the Environment
University of Sunderland
Benedict Building
St George's Way
SUNDERLAND SR2 7BW, UK.
phone +44 (0)191 515-3831
fax +44 (0)191 515-3834
email: m.h.smith@sunderland.ac.uk

Award No. N00014-96-1-0321
http://sunspot.nosc.mil:80/543/eopace/eomain.html

LONG-TERM GOALS

The aim of this project is to characterise the aerosol found within the littoral zone for a wide range of conditions, and subsequently quantify the effects of this aerosol on the propagation of IR radiation and hence Naval electro-optical systems. Measurements of aerosol concentration are used to calculate optical extinctions for a given set of environmental conditions and thus validate aerosol optical depths estimated from other indicators such as more easily measured environmental factors or satellite imagery. Such observations of aerosol concentration and composition will contribute to the development and validation of mesoscale models incorporating aerosol sources, sinks and transport.

OBJECTIVES

The primary objective of the current work has been the characterisation of accumulation mode aerosol ($0.05 < r < 1.5$ µm), within the littoral zone at a variety of locations. In order to achieve this, a thermal analytical, 'volatility' technique has been utilised. Simultaneous soot carbon loadings have been recorded using an Aethalometer in order to validate the volatility measurements and simultaneously provide a useful indication of the magnitude of anthropogenic aerosol input into the measured air masses. The effects of aerosol composition upon atmospheric extinction coefficients at both visible and infra-red wavelengths may then be examined and measurable meteorological and physical oceanographic parameters identified, which can be used to indirectly estimate surf zone aerosol production

APPROACH

The thermal analytical system which is used in determining the concentrations and composition of sub-micron aerosol is based upon a Particle Measuring Systems ASASP-X optical particle counter which is capable of measuring particle radii between 0.05 to 1.5µm. This counter is supplied with particles from a quartz heater tube which undergoes a temperature cycle from near ambient to approaching 1000 °C. Aerosol species which pass through this heated tube and are volatilised at characteristic

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE **Air Mass Characterisation During EOPACE: Aerosol Composition and Concentration**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Sunderland,Centre for Marine and Atmospheric Sciences,St George?s Way,Sunderland SR2 7BW, UK.,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

temperatures. The presence or absence of aerosol species at specific points during the temperature cycle of the heater tube may then be used to identify the predominant aerosol components of the sampled air mass.

This volatility technique has previously been used in the littoral zone, (Smith and O'Dowd, 1996), where the ability to derive soot carbon measurements from the thermal response of the aerosol was demonstrated. Particles larger than approximately 1 μm are measured separately using the combination of an FSSP-100 and an OAP-230X which measure aerosol ranges from 0.25 to 23.5 μm, and 5 to 150 μm in diameter respectively.

WORK COMPLETED

Data collected during the previous 7 EOPACE projects (Jensen, 1995) has been analysed. Atmospheric extinction coefficients at visible and infra-red wavelengths on the windward and leeward sides of the active surf zone have been calculated and compared for periods of onshore and offshore wind flow during the EOPACE projects IOP#4 and IOP#7 using Mie processing algorithms (Bohren and Huffman, 1983). The relationship between more easily measured environmental parameters, in particular surf height and the calculated extinction coefficients has been investigated.

Extensive aerosol measurements have been made at the seaward end of the USACE Field Research Facility pier during the EOPACE IOP#9 field project at Duck, N.C (February - March 1999). The thermal analytical system mentioned above was used to record volatility aerosol composition data throughout the project. Soot carbon loadings were measured using an Aethalometer and aerosol measurements using an FSSP-100 and an OAP-230X were made throughout the project. A tandem volatility system utilising twin DMAs connected by a cycling heater was also used intermittently to measure the composition of small aerosol.

Preliminary analysis of the data obtained during the IOP#9 EOPACE field project has been completed and uploaded to the EOPACE web site to enable access by the rest of the EOPACE research group. Further analysis and post-processing of the seaspray data collected using the OAP and FSSP, including the calculation of 10, 30 and 60 minute mean spectra and the fitting of fifth-order polynomials to these spectra is almost complete and will be uploaded to the EOPACE web site shortly.

RESULTS

Analysis carried out on aerosol data supplied to associated participants in the EOPACE Program has been reported elsewhere (De Leeuw *et al*, 1997, Gathman & Smith, 1997, Smith & Hill, 1997, Veefkind *et al*, 1997)

Periods of onshore wind flow during IOP#4 and IOP#7 were identified and where aerosol data was available at both the windward and leeward sides of the surf zone, the contribution of the surf zone to the ambient aerosol caused by breaking waves in the surf zone was calculated. Fifth-order polynomials were fitted to the aerosol spectra to smooth the statistical noise between the aerosol probe channels. Mean aerosol spectra were found to be higher downwind of the surf zone, irrespective of actual wind direction. Mie calculations (Bohren and Huffman, 1983) were carried out on the additional aerosol contributed by the surf zone in order to produce atmospheric extinction coefficients for the wavelengths 10.06, 3.50, 1.06 and 0.55 µm. In order to simplify the atmospheric extinction calculations, single representative values of the complex refractive index at each wavelength were used for the complete aerosol spectrum, as specified for the four wavelengths in Table 1 below (following Shettle & Fenn, 1979).

Wavelength (µm)	0.55	1.06	3.5	10.6
Refractive Index Real component	1.332	1.367	1.423	1.271
Refractive Index Imaginary component	-5.83E-09	-9.85E-09	-5.64E-03	-4.17E-02

Table 1: Wavelengths and refractive indices used for atmospheric extinction calculations

Temporal variations in the atmospheric extinction due to the surf zone aerosol contribution have been related to other experimentally derived parameters and a reasonable relationship between the surf height and the atmospheric extinction caused by the surf zone aerosol contribution has been shown (Fig 1).

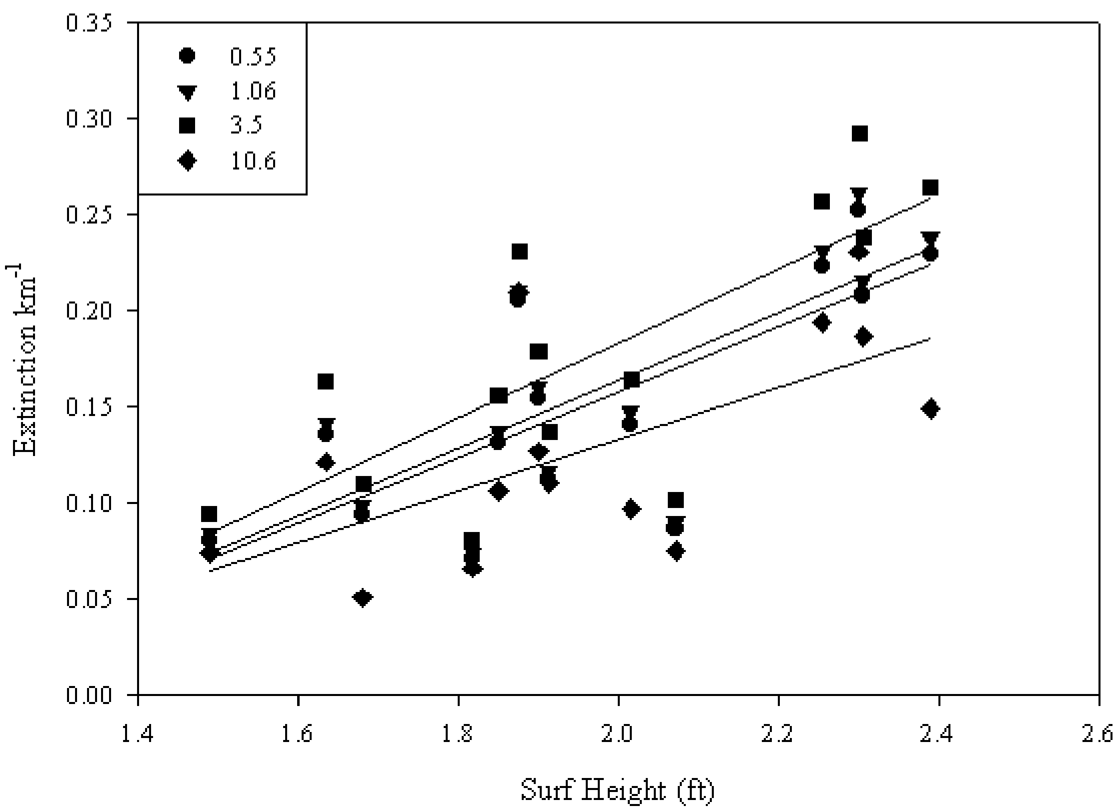

Figure 1: Relationship between surf height and atmospheric extinctions at 4 wavelengths calculated from the contribution of the surf zone to the atmospheric aerosol loading during EOPACE IOP#7.

IMPACT/APPLICATION

These measurements are useful in defining the variability in aerosol concentrations and composition found within the littoral zone and attempt to identify meteorological and oceanographic parameters which are more easily obtained than direct aerosol measurement which may be used to estimate air mass charateristics. The generally low loss rates of the accumulation mode particles which dominate air mass characteristics results in their conservation within a given air mass (with allowances for changes in relative humidity). Hence, current mesoscale meteorological models should be capable of development to incorporate aerosol sources, sinks and transport processes in order to provide predictions of these air mass characteristics. These measurements provide a topographic map of aerosol for use in such mesoscale models.

TRANSITION

This investigation is a component of the EOPACE programme which aims to characterise the coastal atmospheric environment and determine the impact of surf generated aerosols on atmospheric extinction within the coastal environment for evaluation of electro-optical systems performance.

RELATED PROJECTS

The UK Ministry of Defence provide funding via DERA Portsdown Contract No: SSDH300037 to cover participation in the surf zone studies which form an additional element of the EOPACE programme.

REFERENCES

Bohren, C. F. and D. R. Huffman, "Absorption and Scattering of Light by Small Particles", Wiley, 530pp, 1983.

De Leeuw, G, F.P. Neele, A.M.J. van Eijk, E. Vignati, M.K. Hill, and M.H. Smith, "Aerosol production in the surf zone and effects on IR extinction," SPIE Proceedings of the Conference on Propagation and Imaging through the Atmosphere, **3125**, pp. 14-27, 29-31 July, 1997.

Gathman, S.G., and M.H. Smith, "Surf Produced Aerosol," Journal of Aerosol Science, **28** (1), p. S1, Abstracts of the 1997 European Aerosol Conference, Hamburg, Germany, 15-19 Sept 1997.

Jensen, D. R., "EO Propagation Assessment in Coastal Environments", NRaD Internal Report, NCCOSC RDT&E Div, Code 543, San Diego, California, 1995.

Shettle, E. P. and R. W. Fenn, "Models for the Aerosols of the Lower Atmosphere and the Effects of Humidity Variations on Their Optical Properties", Air Force Geophys. Lab., Rept AFGL-TR-79-0214, 84pp, 1979.

Smith, M. H. and C. D. O'Dowd, "Observations of accumulation mode aerosol composition and soot carbon concentrations by means of a high-temperature volatility technique", J. Geophys. Res., **101**, pp. 19,583-19,591, 1996.

Smith, M.H., and M.K. Hill, "Variations in sub-micron aerosol composition during the EOPACE program," SPIE Proceedings of the Conference on Propagation and Imaging through the Atmosphere, **3125**, pp. 28-36, 29-31 July, 1997.

Veefkind, P., G de Leeuw, K.L. Davidson, M. Jordan, C. Wash, P.A. Durkee, M.H. Smith, "EOPACE air mass characterization experiment," SPIE Proceedings of the Conference on Propagation and Imaging through the Atmosphere, **3125**, pp. 66-76, 29-31 July, 1997.